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(71) Applicant: MATSUSHITA ELECTRIC WORKS LTD.

(72) Inventor: YUGAWA Kazuhiko

(72) Inventor: KAWAMOTO Yoji

(74) Agent: ISHIDA Choshichi, Patent Attorney (2 others)

(54) [Title of the Invention] **Electrically powered toothbrush**

[Detailed Description of the Invention]

[0001]

[Field of the Invention] The present invention relates to an electrically powered toothbrush wherein the toothbrush is electrically driven.

[0002]

[Prior Art] Electrically powered toothbrushes proposed to date include types in which the brush is caused to undergo reciprocating motion in the axial direction of the handle to effect "bus"[1] brushing, and types in which the brush is caused to undergo rotary motion about the axis of the handle to effect "rolling" brushing.

[0003]

[Problems the Invention Is Intended to Solve] However, the pass types have the drawback that the brush portion of the toothbrush, when caught between teeth, and in particular between the back teeth, the stroke tends to become shorter, resulting in diminished cleaning action. A drawback of rolling types is the risk of injury to gums due to scouring away of gum tissue. In certain electrically powered toothbrushes the brush portion is attached to a rotary base which rotates back and forth about the axis of projection of the brush portion, but this design requires placing the brush against each individual tooth, so that brushing becomes rather time consuming.

[0004] With the foregoing in view, it is an object of the present invention to provide an electrically powered toothbrush affording a large cleaning area, and more effective brushing.

[0005]

[Means for Solving the Problems] The invention features drive means for inducing, in a brush portion situated on the distal end surface of a stem, reciprocating linear motion in the axial direction of the stem, reciprocating rotary motion about the axis of the stem and,

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[1] [Translator's note: the Japanese usage of "bus" appears to have no English equivalent and may be an idiosyncratic usage by Matsushita Electric Works; see also their US Patent 5,504, 959 which defines "bus" motion as motion whereby "the toothbrush moves in a reciprocating rectilinear fashion in the direction of the axis of its handle."]

simultaneously, reciprocating rotary motion about the axis of projection of the brush portion.

[0006]

[Operation] According to the invention, brush portion motion which is a combination of reciprocating linear motion thereof in the axial direction of the stem, reciprocating rotary motion about the axis of the stem and reciprocating rotary motion about the axis of projection of the brush portion has the advantage of affording a larger cleaning area; of eliminating catching of the brush portion between teeth due to this motion; and of cleaning the entire tooth surface.

[0007]

[Examples] A fuller understanding of the invention is provided through the following examples with reference to the accompanying drawings. [The toothbrush] comprises an elongated hollow cylindrical body 4 housing a battery 41, motor 42 etc.; and a brush attachment 5 linked to a drive shaft 30 that projects from the distal end of body 4. As shown in Fig. 2, the interior of body 4 --which has covers 45, 46 attached to the top and bottom ends thereof-- houses a motor 42, a frame 43 with a cam block C mounted thereon, and a battery holder 44 in which the battery 41 is installed. The drive shaft 30 is also supported on frame 43, and is linked to motor 42 via cam block C. In the drawing, 47 denotes waterproof rubber [element] for preventing [infiltration of] water into the distal end of the body 4; and 48 denotes a bearing for receiving drive shaft 30. The cam block C receives rotational driving force from the motor 42 and causes the drive shaft 30 to undergo reciprocating linear motion in its axial direction, as well as reciprocating rotary motion about its axis; this is discussed later.

[0008] A switch 8 provided at the front of the body 4 comprises two push ON switches 81, 82, a push OFF switch 83, a switch lever 84 undergoing see-saw motion by means of operation of these [switches], contacts (not shown) for [switching the device] ON/OFF as the switch lever 84 toggles, and a switch plate 85. With push ON switch 81 pressed, pressing push ON switch 82 causes the motor to start to operation in a different direction.

[0009] The brush attachment 5 is illustrated in Figs. 3 -5. It comprises a stem 50 configured as a hollow tube whose basal end detachably attaches to the cover 45 of body

4; a holder 51 a holder attached to the distal end of stem 50 so as to allow rotation thereof about the axis of stem 50; a slider 52 housed within holder 51 so as to be slidable in the longitudinal direction; a circular rotary base 55 rotatably supported on a pin 53 projecting from the slider 52; a brush head 56 of circular configuration having a plurality of bristle groups 57 implanted on a first face thereof, and having a hook 58 for engaging the rotary base 5, projecting from a second face thereof; a cover 59 attached to the front opening of holder 51; and coupling rods 60, 61 arranged within stem 50, as shown in Fig. 5(a). A first end of linking rod 61 is insertably coupled with a second end of coupling rod 60, a first end of which detachably couples with the distal end of the drive shaft 30 projecting from body 4; and a second end of linking rod 61 is coupled with slider 52 by means of pin 63.

[0010] The circular rotary base 55, which pivots about the pin 53 of slider 52, comprises a pinion 65 meshing with a rack 64 that is formed on the inside surface of holder 51. When the slider 52 undergoes longitudinal reciprocating sliding motion within the holder 51, the rotary base 55 and the brush head 56 attached to the rotary base 55 undergo reciprocating rotation about the axis of pin 63, i.e., about the axis of projection of the bristle groups 57. During sliding operation of slider 52 the two ends of the pin 63 --which passes through slider 52 and coupling rod 61-- are guided by a flat surface 66 defined by juxtaposed surfaces of holder 51 and cover 59.

[0011] The description now turns to the cam block C in body 4. Cam block C receives rotational driving force from motor 42 and causes the drive shaft 30 to undergo reciprocating linear motion in its axial direction, as well as reciprocating rotary motion about its axis; as shown in Fig. 6 it is composed of three parts: a rotary element 1, a cam 2 and a cam follower 3. The rotary element 1 comprises a shaft portion 11 and a face gear 10, with a shaft hole 12 for passage of a shaft 40. The face gear 10, which meshes with a pinion 49 attached to the output shaft of the motor 42, is arranged concentrically with respect to this shaft hole 12, while the shaft portion 11 is eccentricity therefrom by a distance e_1 shown in the drawing. An engagement groove 13 extending approximately halfway around the circumference is made along the outside at one end of the shaft portion 11.

[0012] Cam 2 has a through-hole 20 passing therethrough, a first end thereof being configured as a reciprocating cam portion 21 eccentricity from through-hole 20 by a distance e_2, and a second end thereof being configured as a rotary cam portion 22 eccentricity from through-hole 20 by a distance e_3 in the opposite direction from the direction of eccentricity of reciprocating cam portion 21. A projection 23 projects into the opening at one end of through-hole 20, and on the outside face of the rotary cam portion 22 there are formed a sloping face 24 whose axis is inclined by an angle θ_1, and a sloping face 25 whose axis is inclined in the opposite direction by an angle θ_2, as will be apparent from Figs. 8 and 9.

[0013] The cam follower 3 is fixed to the bottom end of drive shaft 30, and comprises a first follower portion 31 whose vertical inside edges are contacted by the outside face of reciprocating cam portion 21 of cam 2, and a second follower portion 32 whose two inside edges are contacted by sloping face 24 or sloping face 25 of the rotary cam portion 22. Rotary element 1, which receives rotation drive from motor 42 and rotates about shaft 40, fits rotatably about its shaft portion 11 within through-hole 20 of cam 2, and positioned with the projection 23 of cam 2 aligned with the engagement groove 13 of shaft portion 11. Cam follower 3, on which is drive shaft 30 is supported by means of bearings 48, 48 such that it can slide axially and undergo axial rotation, is arranged with the first follower portion 31 in contact with reciprocating cam portion 21 and with the second follower portion 32 in contact with rotary cam portion 22 as described above.

[0014] Here, the eccentricity e_1 of shaft portion 11 of rotary element 1 is equal to the eccentricity e_2 of reciprocating cam portion 21 of cam 2, while eccentricity e_3 of rotary cam portion 22 differs from these two eccentricities e_1, e_2. As shown in Fig. 7, when the projection 23 of cam 2 is engaged at one end of the engagement groove 13 that extends approximately halfway around the circumference of rotary element 1, the direction of eccentricity of shaft portion 11 and the direction of eccentricity of rotary cam portion 22 are mutually opposed, so that the eccentricity of reciprocating cam portion 21 with respect to shaft 40 goes to zero, that is, reciprocating cam portion 21 is situated concentrically with respect to shaft 40, and the eccentricity of rotary cam portion 22 with respect to shaft 40 equals (e_1 - e_3). As shown in Fig. 7(b), when conversely the projection

23 of cam 2 is engaged at the other end of the engagement groove 13 of rotary element 1, the direction of eccentricity of shaft portion 11 and the direction of eccentricity of rotary cam portion 22 coincide, so that the eccentricity of reciprocating cam portion 21 with respect to shaft 40 is $(e_1 + e_2) = 2e_1$, and the eccentricity of rotary cam portion 22 with respect to shaft 40 equals $(2e_1 - e_3)$. The slope angles of sloping faces 24, 25 correspond to the eccentricity values $(e_1 - e_3)$ and $(2e_1 - e_3)$.

[0015] As the direction of rotation of rotary element 1 determines which end of engagement groove 13 engages projection 23, when rotary element 1 is turned clockwise as indicated by the arrow in Fig. 7(b), the reciprocating cam portion 21 also becomes eccentric with respect to shaft 40, as shown in Fig. 9, and the sloping face 25 of the rotary cam portion 22 contacts the second follower portion 32 of cam follower 3; thus, as the cam 2 rotates the cam follower 3 simultaneously undergoes reciprocating linear motion in the direction of the axis of output shaft 3 [sic], and reciprocating rotary motion within a range corresponding to the axial slope θ_2 of the sloping face 25.

[0016] This motion of the cam follower 3 is transmitted to the drive shaft 30 (which forms an integral unit with cam follower 3), the coupling rods 60, 61, and thence to the slider 52, whereupon reciprocating linear motion in the axial direction is translated into reciprocating sliding motion of the slider 52, and into reciprocating rotation of the rotary base 55 by means of the rack and pinion engagement between the rotary base 55 and the holder 51. Reciprocating rotary motion of cam follower 3 is translated directly into reciprocating rotary motion of the slider 52 and the holder 51. Accordingly, as shown in Fig. 10, the brush head 56, which is attached to the rotary base 55 pivoting on pin 53 of the slider 52, undergoes motion which is a combination of reciprocating linear motion in the axial direction of stem 50 (the stroke $S = (e_1 + e_2)$), reciprocating rotary motion about the axis of stem 50, and reciprocating rotary motion about the axis of pin 53. Transmission of this motion to the bristle groups 57 affords a large cleaning area while avoiding catching of the bristle groups 57 between teeth, since the bristle groups 57 do not remain in any one location for very long. The motion of the bristle groups 57, as viewed from the front, roughly describes an "O" as shown in Fig. 10(b), omitting the reciprocating rotary motion component about the axis of pin 53.

[0017] As noted, the holder 51 receives from drive shaft 30 only reciprocating rotary motion in the axial direction of stem 50, while the slider 52 receives both reciprocating linear motion in the axial direction of stem 50 and reciprocating rotary motion about the axis, in other words, the slider 52 undergoes only reciprocating linear motion with respect to the holder 51, whereby reciprocating rotary motion of the bristle groups 57 about the axis of projection thereof may be easily generated by means of the rack and pinion arrangement described above, or the like.

[0018] When rotary element 1 is turned counterclockwise as indicated by the arrow in Fig. 7(a), as noted, only the rotary cam portion 22 becomes eccentric with respect to shaft 40, and the reciprocating cam portion 21 becomes concentric with shaft 40, whereupon as shown in Fig. 8 the reciprocating cam portion 21 simply rotates within the first follower 31 of the cam follower 3; however, the rotary cam portion 22, whose sloping face 24 is currently in contact with second follower portion 32, in association with this rotation causes cam follower 3 to undergo reciprocating rotary motion within a range corresponding to the axial slope θ_1 of the sloping face 24. This motion of cam follower 3 imparts to bristle groups 57 only reciprocating rotary motion about the axis of stem 50, providing a rolling brush action.

[0019] The range of reciprocating rotary motion in the latter case --i.e. rolling brush action-- is smaller than the range of reciprocating rotary motion in the former case --i.e. complex motion-- in order to avoid damage to the gums possibly caused by rolling brushing; however, these may be made the same. In the case of the former complex motion, the inclusion of rotation of the bristle groups 57 and reciprocating linear motion thereof in the direction of the longitudinal axis of stem 50 means that event if there is a large component of reciprocating rotary motion about the axis of stem 50, the bristle groups 57 will not scour away gum tissue in any single location, so as not to damage the gums.

[0020] The coupling spring 62 depicted in Fig. 5(c) can be used in place of the coupling rod 61 described earlier; where a brush attachment 5 employs this coupling spring 62 in place of coupling rod 61 the reciprocating rotary motion component is absorbed by the coupling spring 62 so that only reciprocating linear motion is transmitted to the slider 52,

in which case the bristle groups 57 undergo reciprocating linear motion and reciprocating rotary motion about the axis of pin 53. Naturally, an ordinary brush attachment 5 like those proposed to date could be used as well, enabling a single body 5 [sic] to perform several different brushing operations.

[0021] In the example illustrated in Fig. 11, an eccentric portion 15 having an eccentricity e_5 is formed at the basal portion of a shaft portion 11 whose eccentricity with respect to a rotary element 1 is e_1, with a cam 2 having an eccentricity e_2 equal to the eccentricity e_1 of shaft portion 11 being arranged on the outside of the distal end of shaft portion 11, and arranged with the upper and lower inside edges of a first follower portion 31 of a cam follower 3 contacting the eccentric portion 15 and the left and right inside edges of a second follower portion 32 contacting cam 2. As this rotary element 1 rotates in a first direction, as shown in Fig. 12(a), the eccentricity of cam 2 with respect to shaft 40 goes to $(e_1 + e_2)$ so that cam follower 3 undergoes a combination of vertical reciprocating linear motion of stroke S ($S = 2e_5$) corresponding to the eccentricity e_5 of eccentric portion 15 received by the first follower portion 31 thereof, and reciprocating rotary motion corresponding to the eccentricity $(e_1 + e_2)$ of cam 2 received by second follower portion 32, [this combined motion] defining an elliptical path, to produce motion of the bristle groups 57 like that illustrated in Fig. 10, in a manner analogous to the previous example.

[0022] When the rotary element 1 rotates in the opposite direction, the eccentricity direction of cam 2 and the eccentricity direction of shaft portion 11 are mutually opposite and cancel each other out, as illustrated in Figs. 12(b) and (c), so that the eccentricity of cam 2 with respect to shaft 40 goes to zero. Therefore the cam follower 3 undergoes vertical reciprocating linear motion only, this being due to the eccentric portion 15 of eccentricity e_5. In other words the bristle groups 57 undergo motion which is a combination of reciprocating linear motion in the direction of the axis of stem 50, and reciprocating rotary motion about pin 53.

[0023] The example depicted in Fig. 13 has been designed so that operation of the motor 42 need not be switched between different directions of rotation. The shaft portion 11 of rotary element 1 is provided with an eccentric portion 15 and with a similarly

eccentricity rotary cam portion 16; cam follower 3 and drive shaft 30 are made to undergo reciprocating linear motion by eccentric portion 15, and cam follower 3 and drive shaft 30 are made to undergo reciprocating rotary motion by rotary cam portion 16. This arrangement also produces motion of the bristle groups 57 like that illustrated in Fig. 10. By spacing the eccentricity directions of eccentric portion 15 and rotary cam portion 16 90° apart so that reciprocating linear motion and reciprocating rotary motion are out-of-phase, and aligning the dead point of reciprocating rotary motion with the dead point of reciprocating linear motion of stroke S as shown in Fig. 14(a), the motion of the bristle groups 57, viewed from the front, will describe an "S" as shown in Fig. 14(b), excluding the component of reciprocating rotary motion about pin 53.

[0024] As shown in Figs. 15 and 16, where the inside face of second follower portion 32 is given a tetralobate configuration so as to produce reciprocating rotary motion in cam follower 3, the eccentric component of the rotary cam follower will cancel out every 90°, and during each rotation of the rotary element 1 the cam follower will be induced to undergo two reciprocating rotary motions, so that the motion of the bristle groups 57, viewed from the front, will describe an "8" as shown in Fig. 16(b), excluding the component of reciprocating rotary motion about pin 53.

[0025] Fig. 17 shows a brush attachment 5 comprising a single brush head 56. The electrically powered toothbrush herein can be used with ordinary brush attachments and interdental cleaning attachments, by attaching these to drive shaft 30.

[0026]

[Effects of the Invention] According to the invention set forth herein, the brush portion undergoes motion which is a combination reciprocating linear motion in the axial direction of the stem, reciprocating rotary motion about the axis of the stem, and reciprocating rotary motion about the axis of projection of the brush portion, this motion being more complex and covering a wider area than do conventional pass brushing and rolling brushing, allowing the entire tooth surface to be enveloped during brushing, facilitating brushing between teeth and gums, between teeth, and of biting surfaces, this motion also serving to prevent the brush portion from becoming caught between teeth, so that brushing may be accomplished effectively.

[0027] Further, where the brush portion comprises a holder provided at the distal end of the stem for receiving from the drive means only reciprocating rotary motion about the axis of the stem , a slider slidably arranged in the holder for receiving from the drive means reciprocating linear motion in the axial direction of the stem and reciprocating rotary motion about the stem axis, and a motion conversion portion for translating slide of the slider with respect to the holder into reciprocating rotary motion of the brush portion about the axis of projection thereof, these three motions can be produced by means of a relatively simple arrangement.

[Brief Description of the Figures]

[Figure 1] A perspective view depicting an embodiment of the invention.

[Figure 2] A sectional view of the body.

[Figure 3] A sectional view of the brush attachment.

[Figure 4] An exploded perspective view of the brush attachment.

[Figure 5] (a) An exploded perspective view of the coupling shaft housed in the stem; (b) a sectional view of the brush attachment; and (c) a perspective view of a coupling spring used in place of the coupling shaft.

[Figure 6] An exploded perspective view of the cam block.

[Figure 7] (a), (b) are plan views showing eccentricity in the cam block.

[Figure 8] Depicts an operation of the cam block, (a) being a horizontal section and (b) being a longitudinal section.

[Figure 9] Depicts another operation of the cam block, (a) being a horizontal section and (b) being a longitudinal section.

[Figure 10] (a), (b) are illustrative diagrams of operation of the brush portion of the toothbrush.

[Figure 11] An exploded perspective view another example of a cam block.

[Figure 12] Depicts another operation of the above, (a) being a horizontal section depicting rotation in a first direction and (b), (c) being a horizontal and longitudinal sections depicting rotation in the other direction.

[Figure 13] An exploded perspective view another example of a cam block.

[Figure 14] (a), (b) are illustrative diagrams of operation of the brush portion of the toothbrush where another example of the cam block is employed.

[Figure 15] An exploded perspective view another example of a cam block.

[Figure 16] (a), (b) are illustrative diagrams of operation of the above.

[Figure 17] A perspective view another example of a brush attachment.

[Key]

5: brush attachment

50: stem

57: bristle group

5: brush attachment

50: stem

57: bristle group

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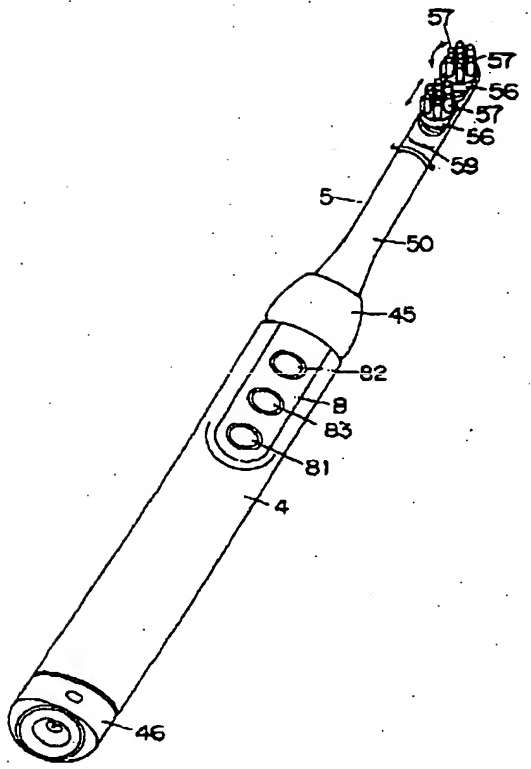
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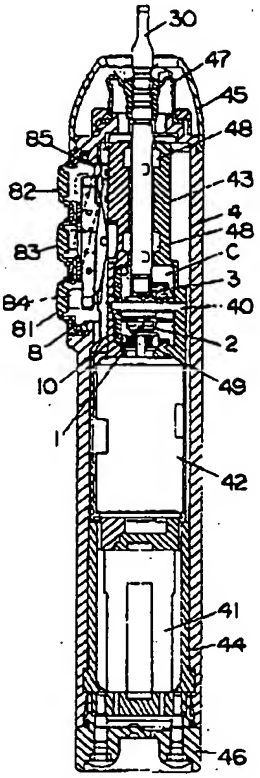
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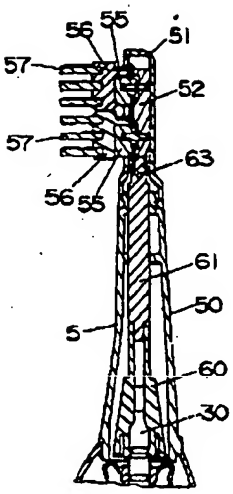
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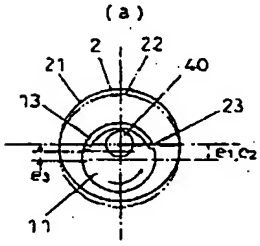
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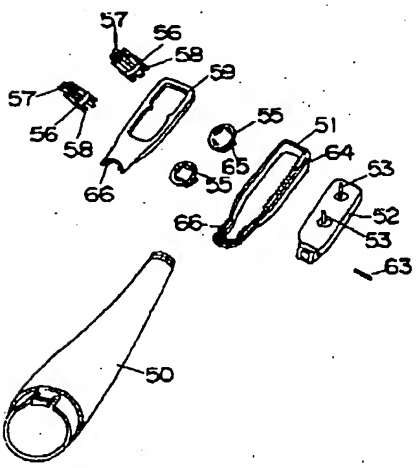
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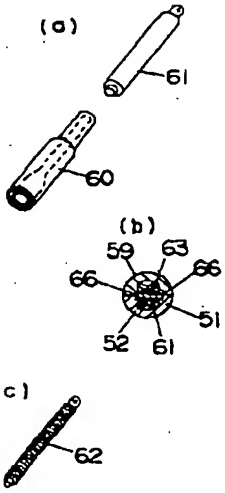
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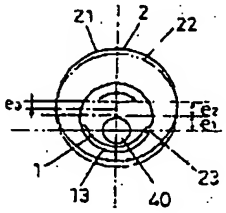
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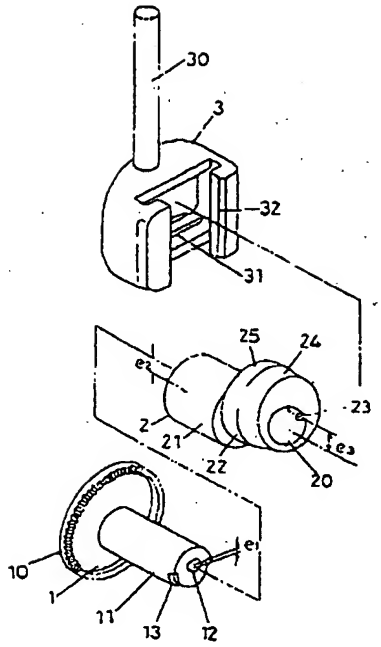

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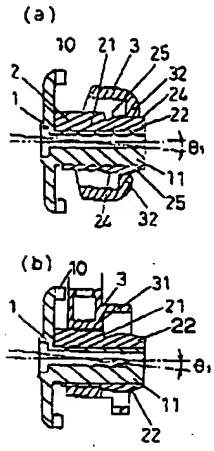

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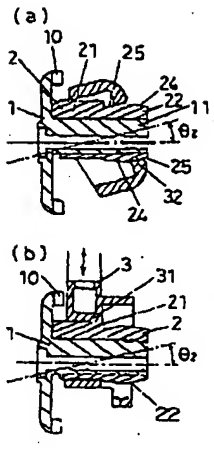

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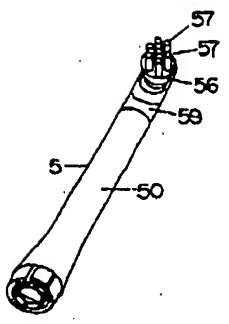

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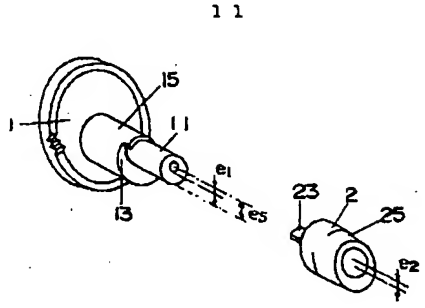

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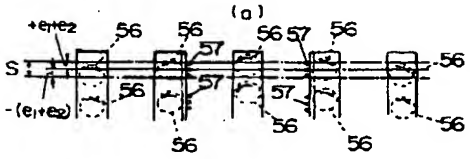

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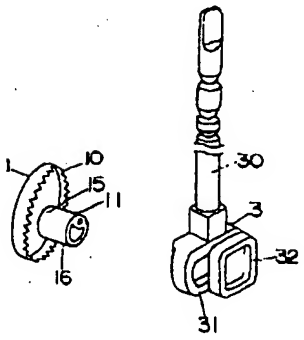

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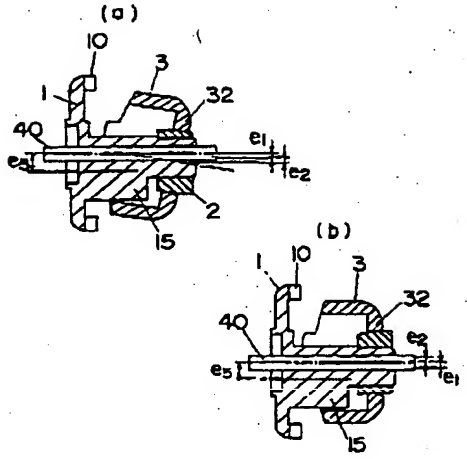
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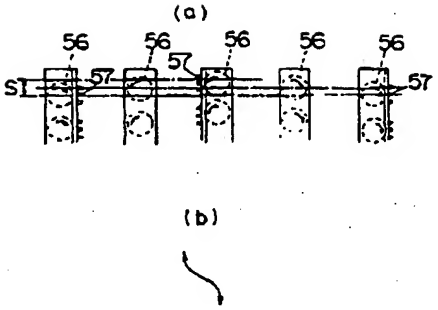
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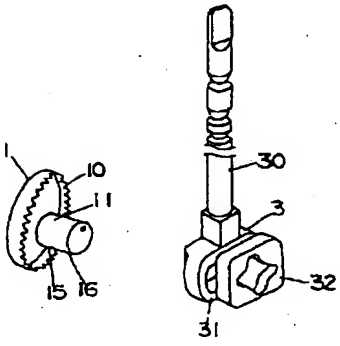
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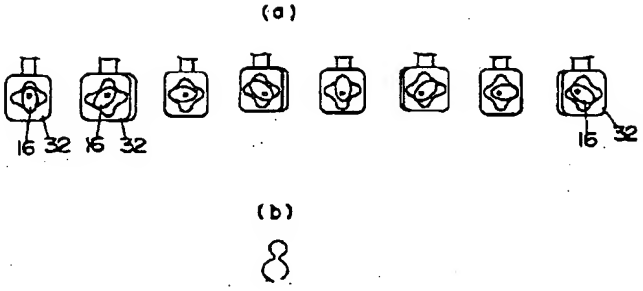
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